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Surface Scanning Soft Tissues

Nick J. AVIS, John McCLURE and Frederic KLEINERMANN
Cardiff School of Computer Science, Cardiff University, Queen's Buildings, 5 The Parade, Roath, Cardiff CF24 3AA, United Kingdom
Directorate of Laboratory Medicine, Manchester Royal Infirmary, Oxford Road, Manchester, M13 9WL, United Kingdom
Research Group WISE, Department of Computer Science, VrijeUniversiteit Brussel, Pleinlaan 2, B-1050 Brussel, Belgium

Abstract. We investigate and report a method of 3D virtual organ creation based on the RGB color laser surface scanning of preserved biological specimens. The surface attributes of these specimens result in signal degredation and increased scanning time. Despite these problems we are able to reproduce 3D virtual organs with both accurate topology and colour consistency capable of reproducing pathological lesions.

1. Introduction

3D computer based training tools and surgical simulators are emerging as useful teaching tools in a variety of different situations [1]. The construction of these simulators in challenging in many areas. Whilst there has been considerable interest and developments recently regarding the physically based modelling of soft tissues to allow real time deformation due to surgical interaction [2], the visual representation of both normal and diseased tissues and organs has been a relatively neglected area. Existing 3D virtual organ models are often "hand crafted" using conventional 3D content creation tools employing standard polygonal modeling and texture mapping techniques. As such it is difficult and time consuming to create a library of 3D virtual organs to expose the trainee to a range of virtual organs that represent biological variability and disease pathology. Furthermore, such virtual organs must be both topologically correct and also exhibit color consistency to support the identification of pathological lesions.

We investigated a new method of virtual organ creation based on a commercially available RGB color laser surface scanning technology and point based rendering techniques applied in the first case to a number of preserved biological specimens. These specimens represent the "gold standard" anatomical teaching resources presently available within teaching hospitals.

2. Surface Scanning

The test objects included: a plastic facimile of a human skull, a rubber model of a human liver, untreated porcine and ovine material obtained from a local high street butcher, a plastinated human heart and preserved porcine and human specimens. Specific permissions from the relevant authorities were sought and obtained to allow the use of human materials of these purposes. Prior to scanning the preserved specimens were removed from their jar, washed and excess water removed via light application of an absorent lint-free cloth. The specimens were scanned using the Arius3D system (www.arius3d.com). This system employs a scanning laser and the triangulation technique to determine the distance of each measured point. The laser head is mounted on a coordinate measuring machine (CMM). Unlike most laser scanning systems the Arius3D scanner records color information as well as distance at each measured point by combining the signals from three color lasers (red, green and blue) and constructs a "texture" image which is aligned and at the same spatial resolution as the reconstructed surface [3]. Since the pitch between measured point is small (of the order of 100 to 200 micros) a visual representation of the object can be presented using point based rendering techniques without the need to generate a polygonal surface representation [4]. Conversion to a surface representation can be performed as a post data acquisition and merging operation using a number of commercially available third party tools.

3. Results

Unlike the plastic and rubber specimens all the biological specimens exhibited highly reflective surfaces. In addition the objects themselves were not self supporting and were highly deformable.

In many scan passes the system was unable to detect a signal and effect a reconstruction of the scanned area. This was due to the reflective nature of the surface being scanned. Similar problems had previously been encountered when attempting to use photogrammetry and other laser based surface scanning technologies on similar specimens [5]. The need for multiple scans at slighly different angles to obtain sufficient data to effect a reconstruction proved problematical both in terms of increased scan time and dataset size, but also regarding issues surrounding the movement of the specimen. Figure 1 show the test specimens and the reconstructed "virtual organ" using the Arius3D scanner data and point based rendering techniques.

4. Discussion

The utility of virtual organs showing pathological lesons depends on color consistency in the representation of the lesions. The Arius3D system is unique, as far as we are aware, in that it recovers both toplogy and color from the scanned object. The physics associated with surface and sub-surface reflections and how these affect the scanner require further investigation. Nevertheless of the test objects scanned we were able to effect a 3D reconstruction albeit with considerably more scan time and post processing effort that originally anticipated.

5. Conclusion

The surface scanning of biological soft tissues promises a quick and easy means to construct virtual organs for use within surgical simulators and other computer based medical

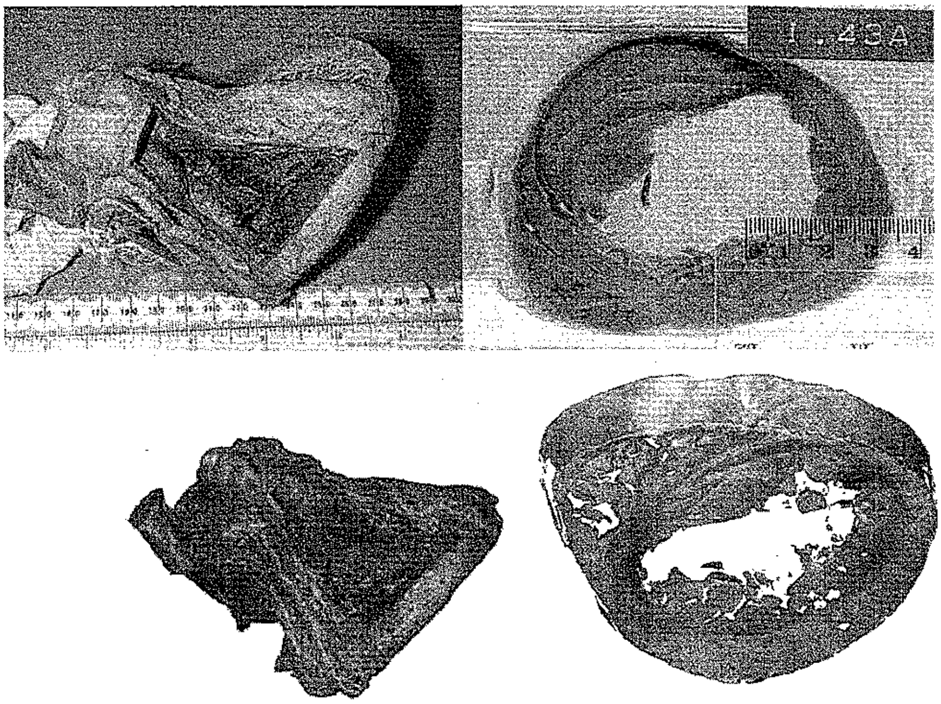

Figure 1. Test objects and virtual organ representations. The virtual organs contain 13,385,767 and 585,508 data points respectively. The images show models using point based rendering techniques and have not been converted to a polygonal mesh. Color consistency within and between models is important to support pathological lesion identification.

education packages. However, as outlined here, the surface and subsurface reflections associated with the tissues of many organs, present additional challenges to scanning systems and result in data drop-out. This combined with the deformable nature of much of this material and the challenge of a simple and effective means of capturing the surface topology and texture of deformable biological specimens in-vivo or ex-vivo remains.

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